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Hildebrandt et al.

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(54) **BELT FINISHING DEVICE, BELT FINISHING SYSTEM AND METHOD FOR PRODUCING A BELT FINISHING DEVICE**

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(30) **Foreign Application Priority Data**

Oct. 1, 2012 (EP) 12186775

(51) **Int. Cl.**

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B24B 21/08	(2006.01)
B24B 21/02	(2006.01)
B24B 21/06	(2006.01)
B24B 35/00	(2006.01)

(52) **U.S. Cl.**

CPC ***B24B 21/20*** (2013.01); ***B24B 21/02*** (2013.01); ***B24B 21/06*** (2013.01); ***B24B 21/08*** (2013.01); ***B24B 35/00*** (2013.01); *Y10T 29/49* (2015.01)

(58) **Field of Classification Search**

CPC B24B 21/02; B24B 21/06; B24B 21/08; B24B 21/20

USPC 451/49, 302, 303, 309, 311

See application file for complete search history.

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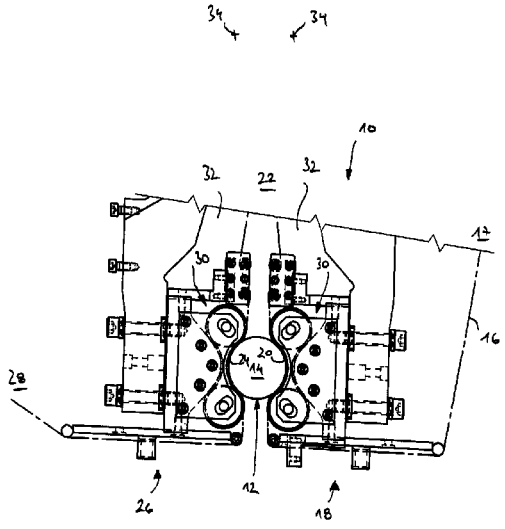
(57) **ABSTRACT**

A belt finishing device includes a finishing belt, two bearing surfaces that are spaced-apart in a running direction of the finishing belt, and a pressing device for pressing the finishing belt against a workpiece surface. The pressing device has a pressure belt that is supported on the two spaced-apart bearing surfaces. At least one of a bearing surface and the pressure belt have a profile that deviates in a width direction of the finishing belt from a straight course.

17 Claims, 17 Drawing Sheets



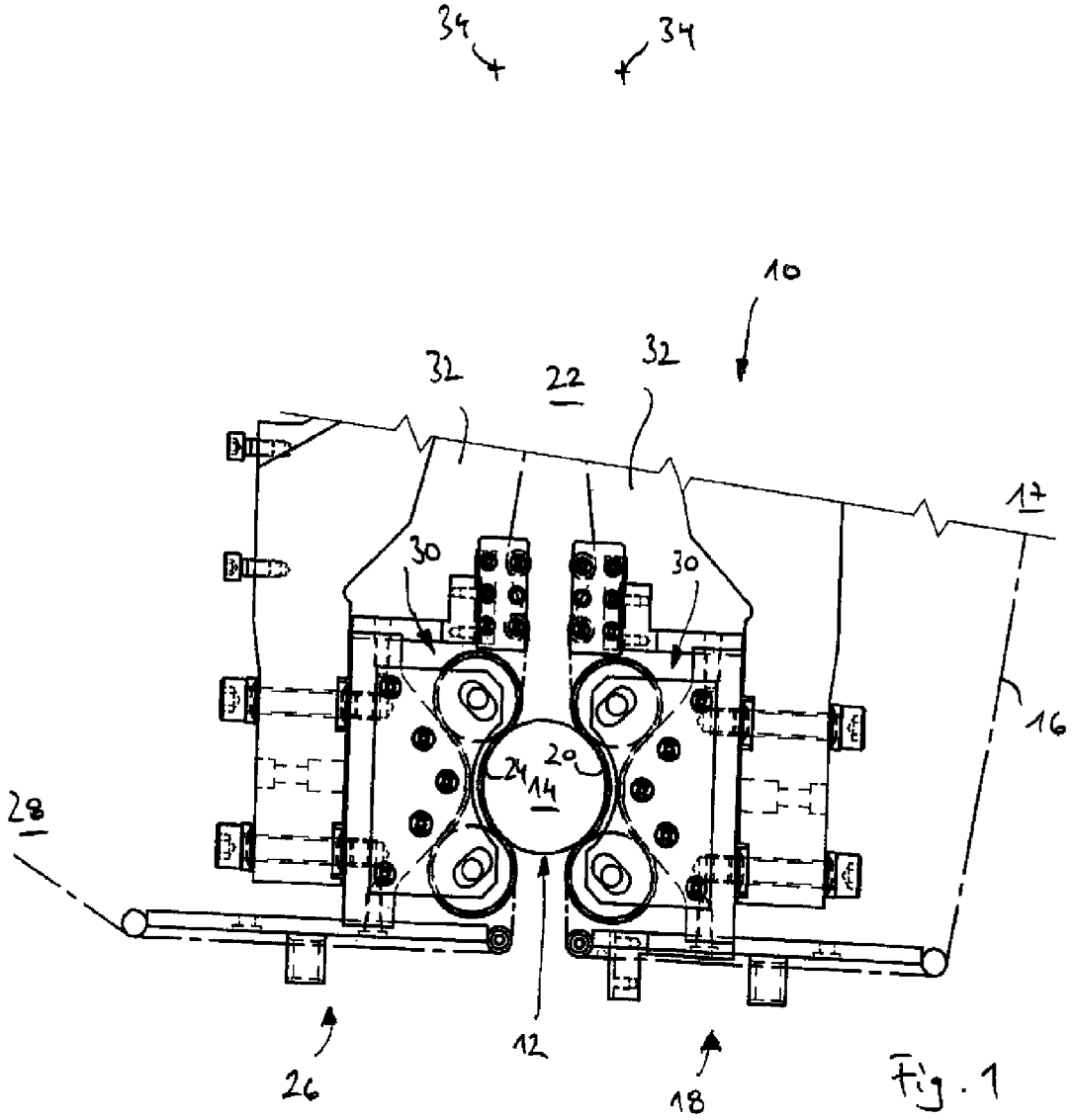


Fig. 1

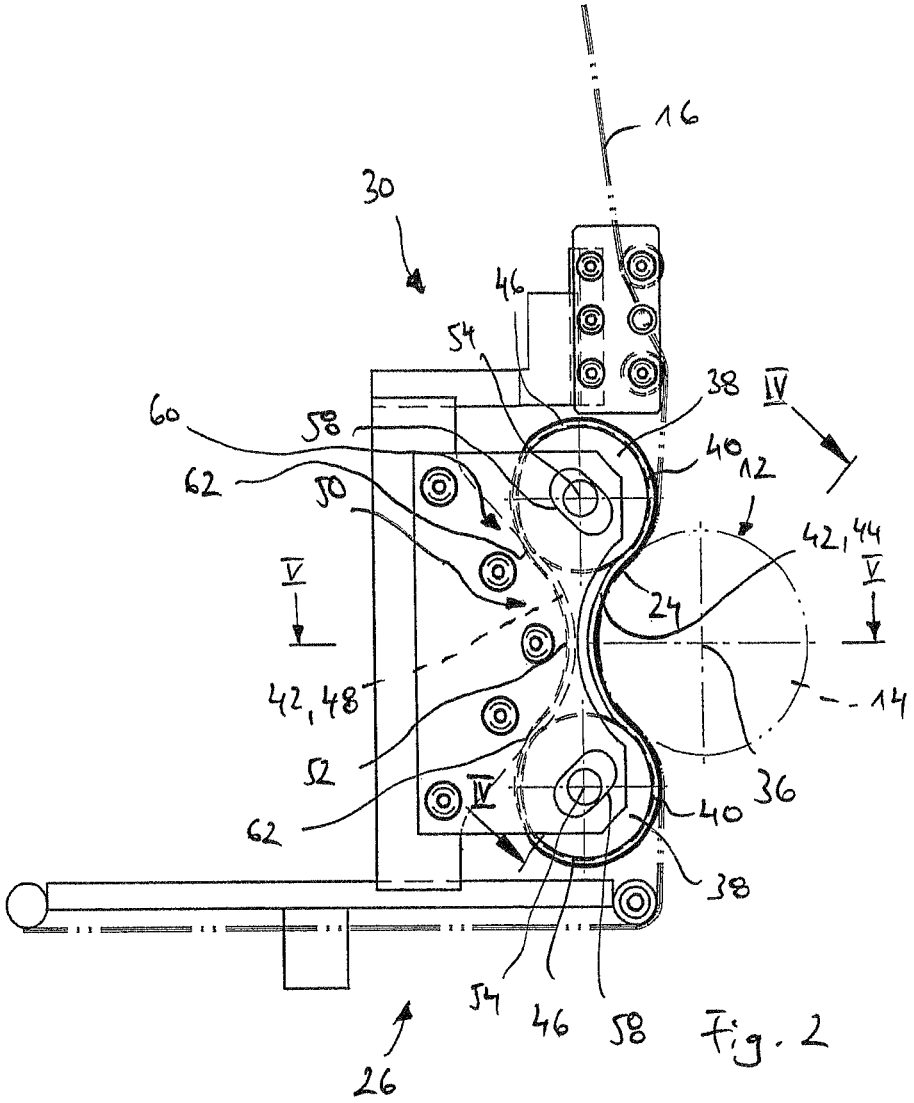

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Fig. 2

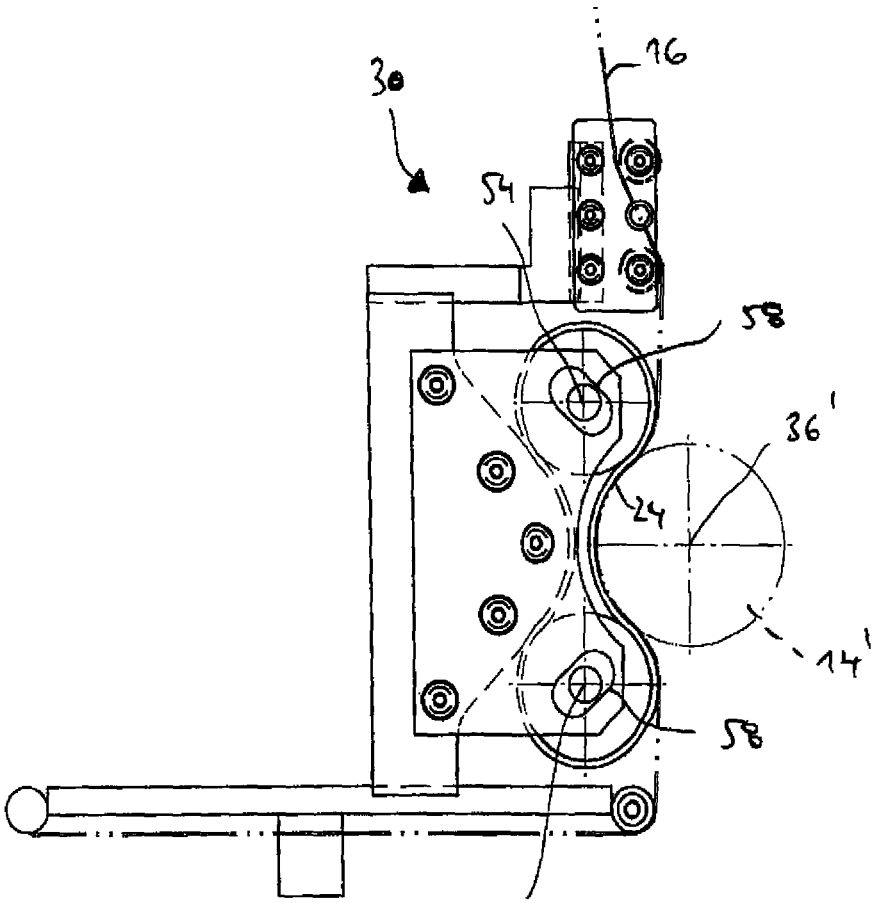


Fig. 3

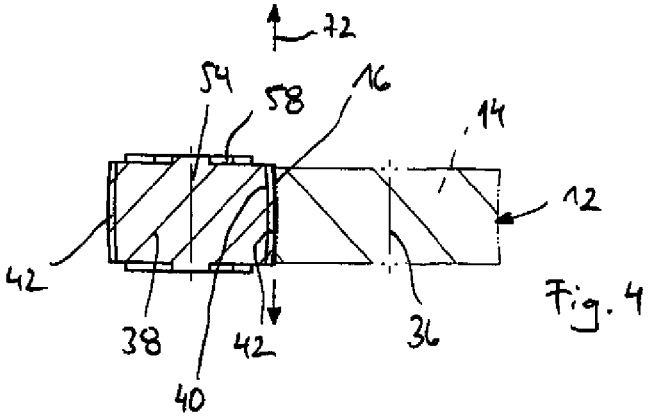


Fig. 4

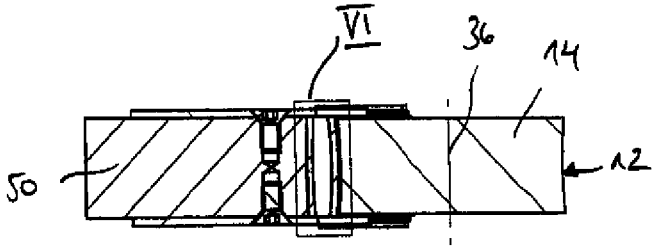


Fig. 5

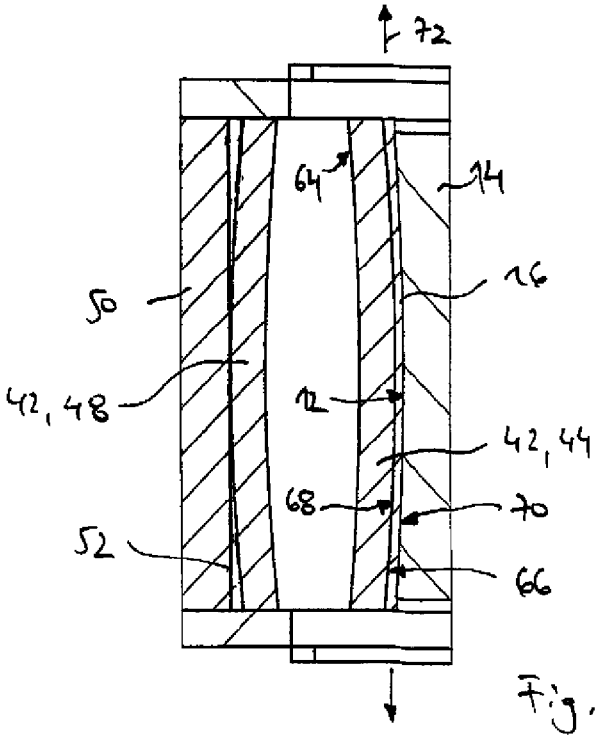


Fig. 6

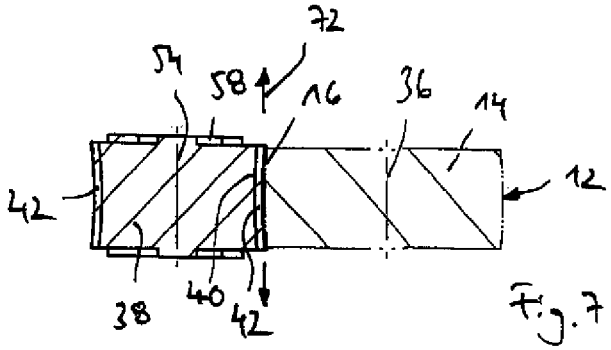
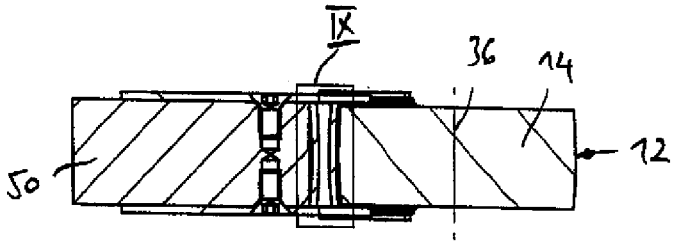


Fig. 7



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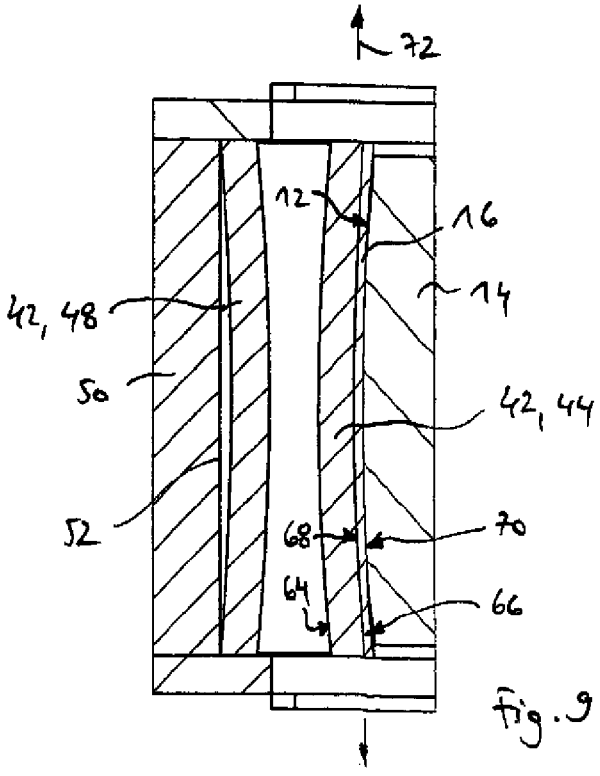

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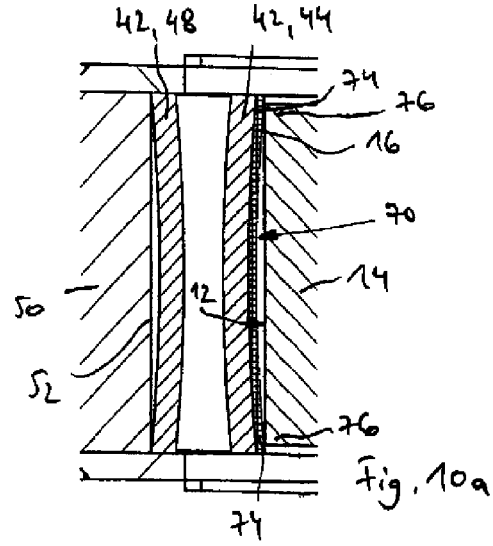

Fig. 10a

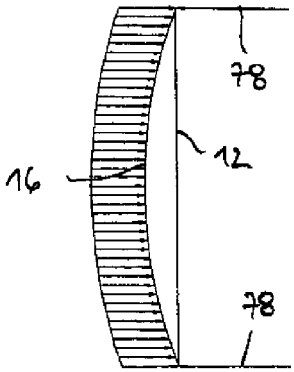

Fig. 11a

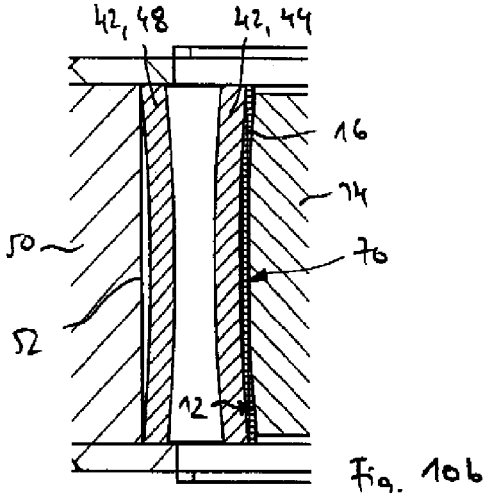

Fig. 10b

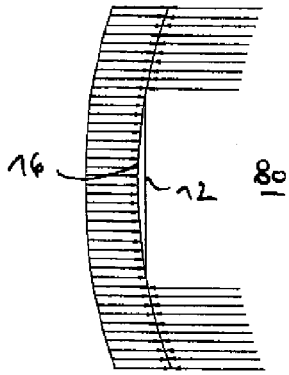

Fig. 11b

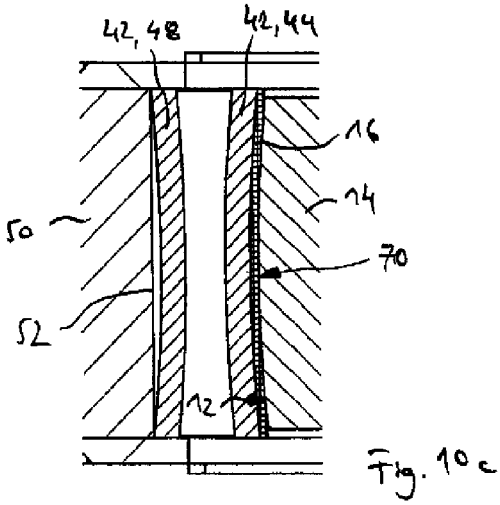

Fig. 10c

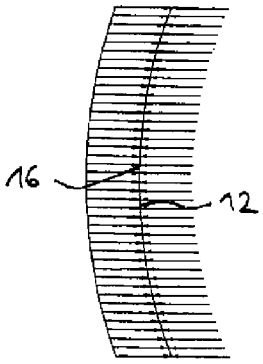

Fig. 11c

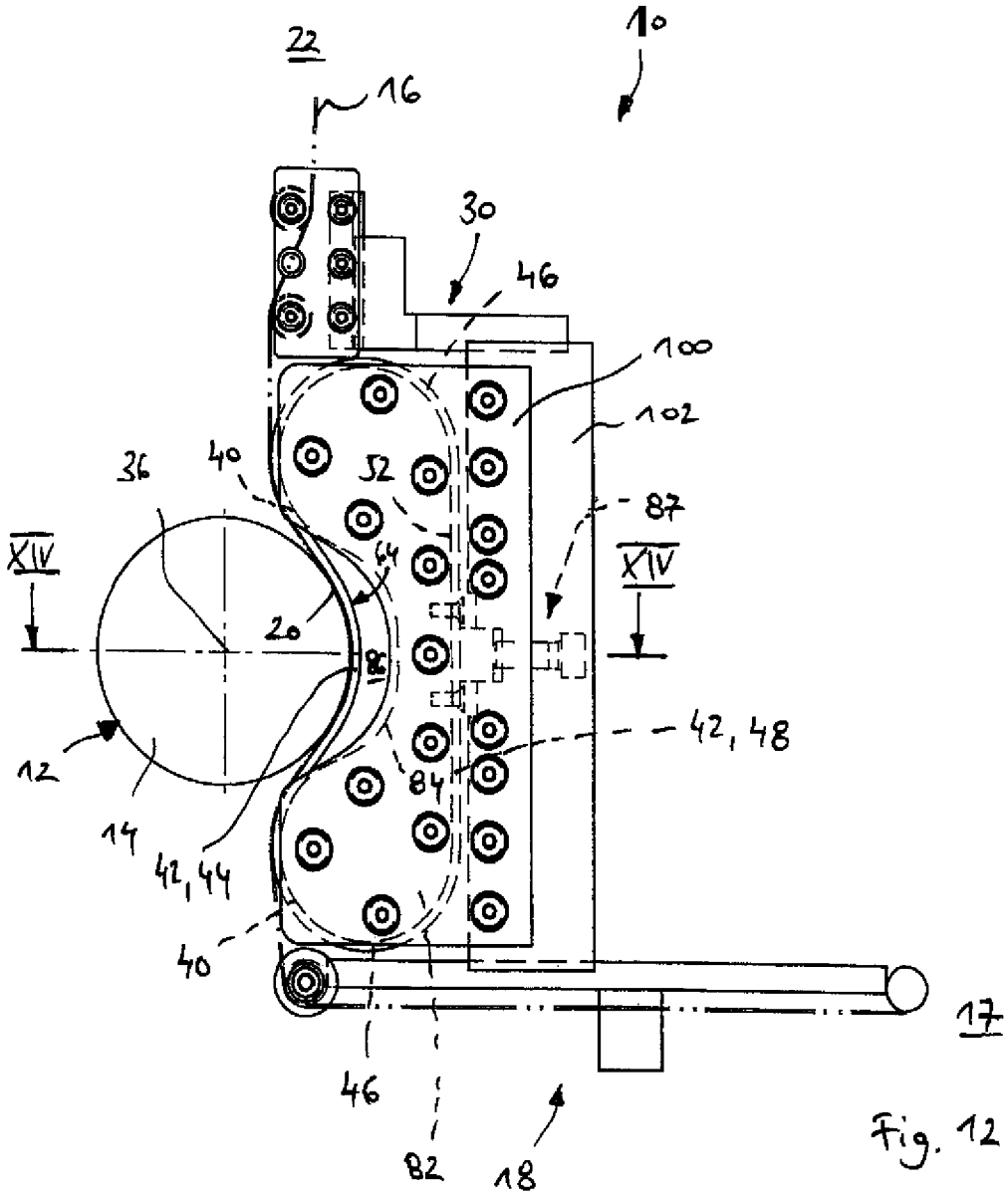
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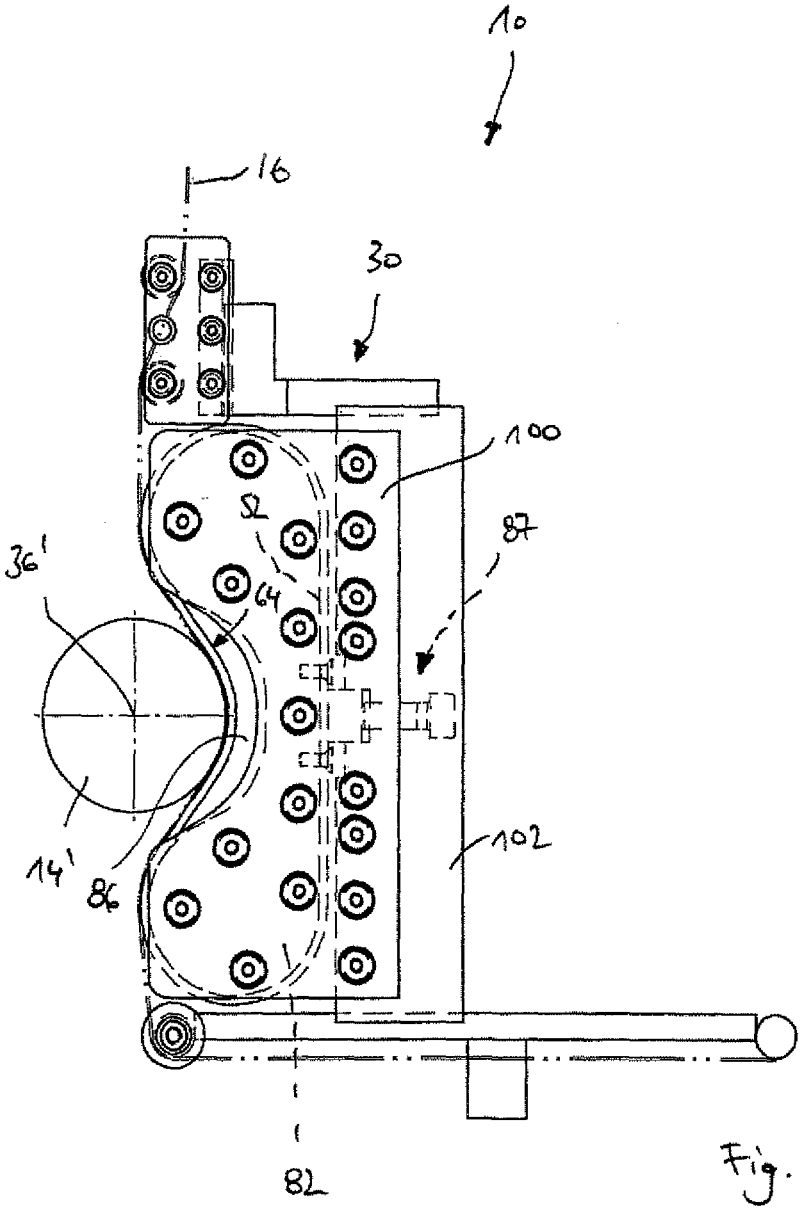
Fig. 12



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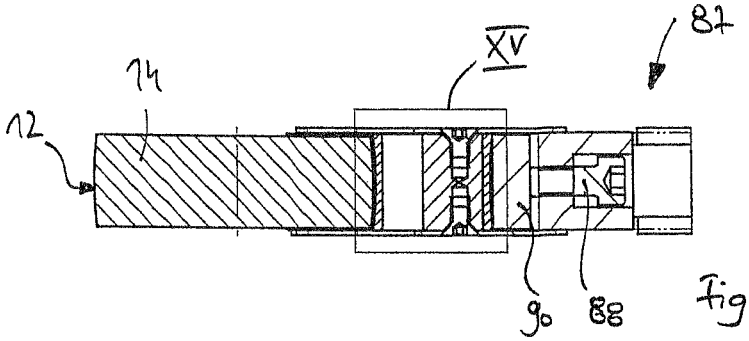

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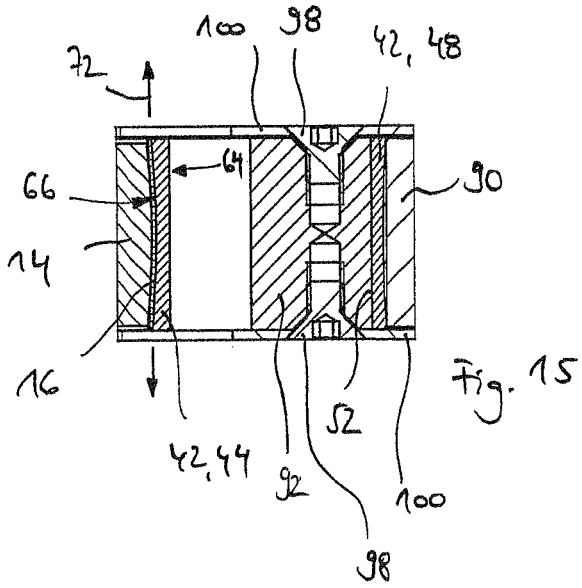

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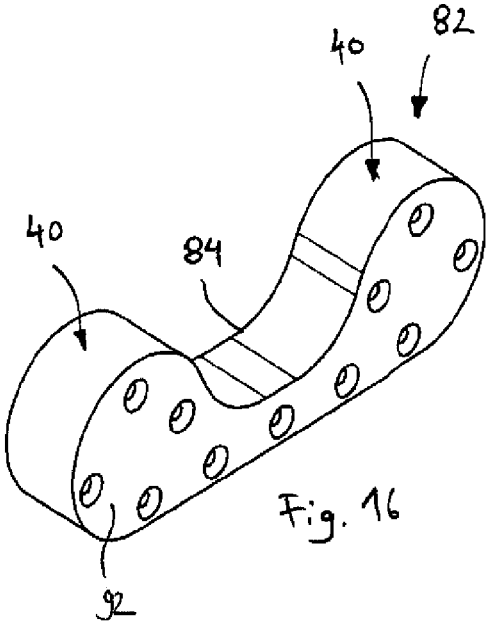

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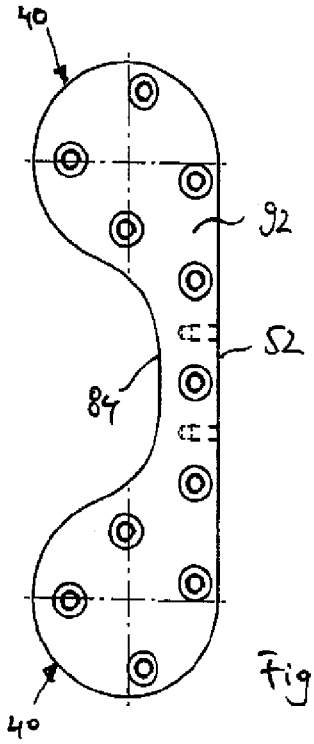

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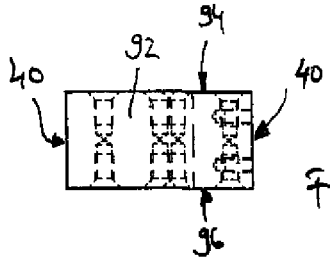

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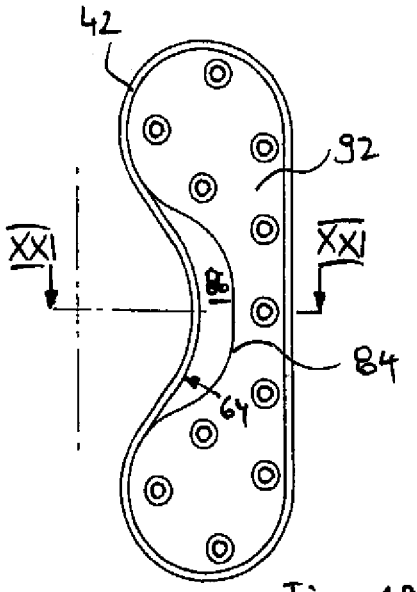

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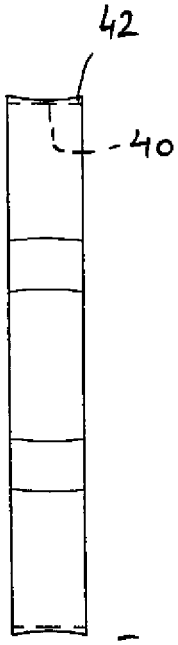

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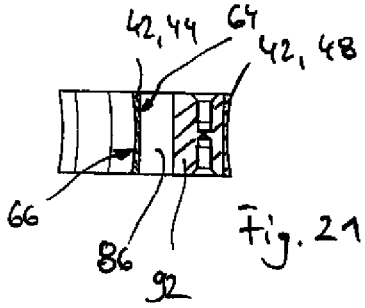

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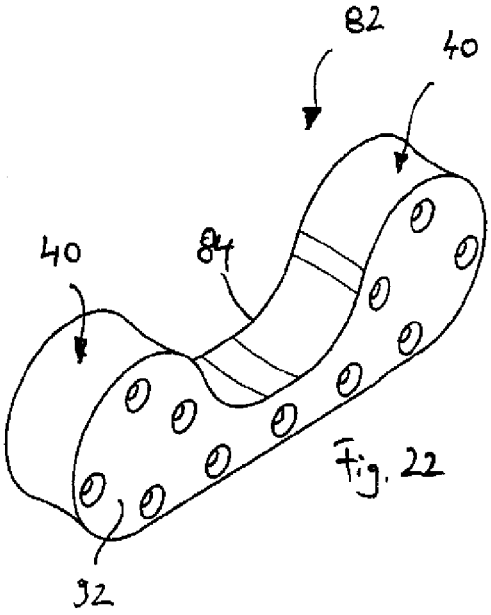

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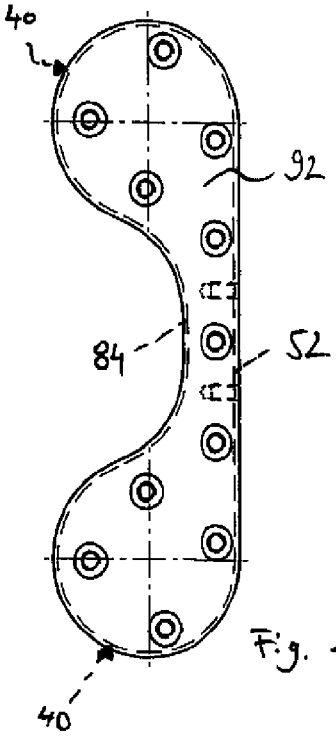
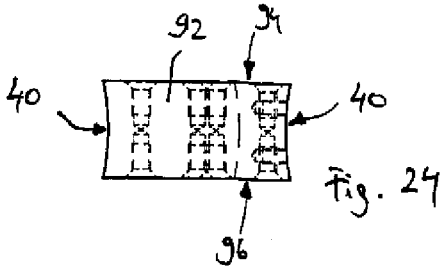


Fig. 23



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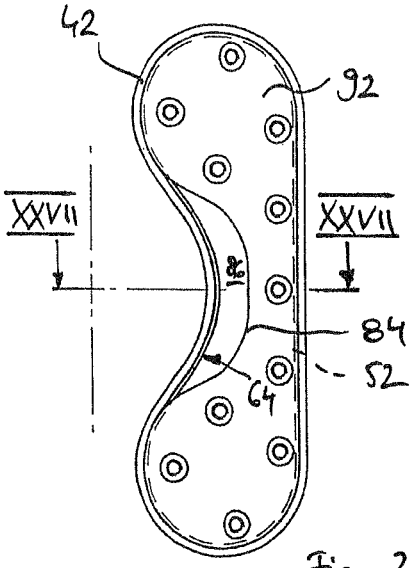

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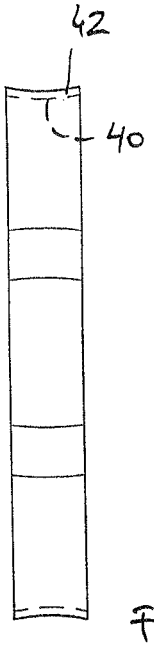

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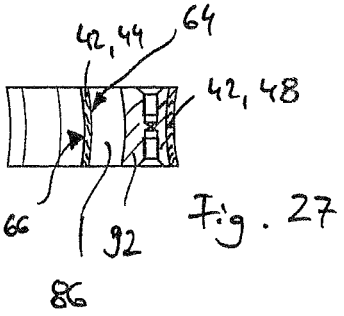

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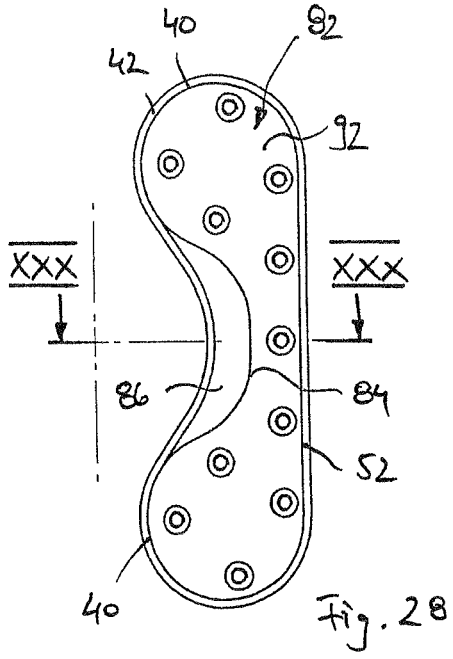

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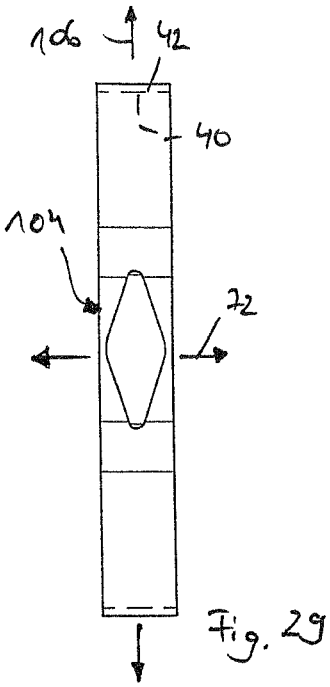

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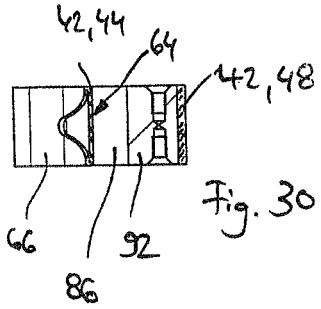

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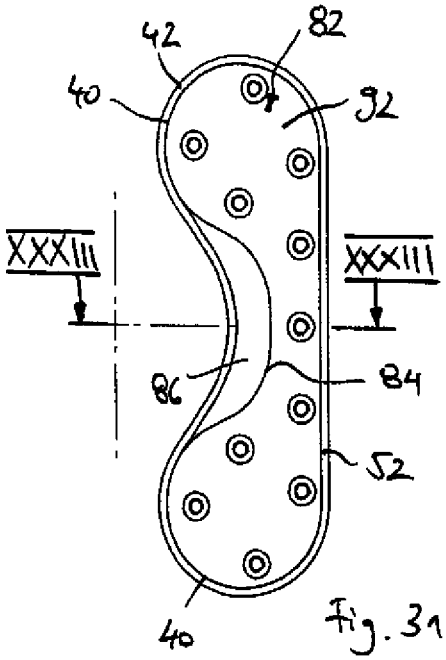

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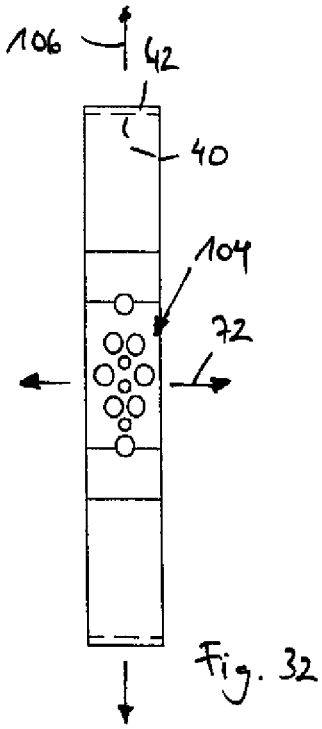

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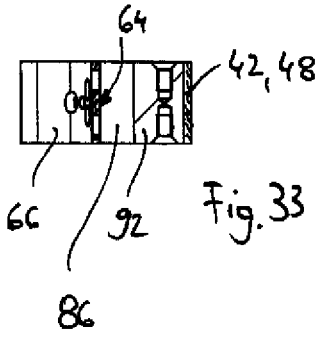

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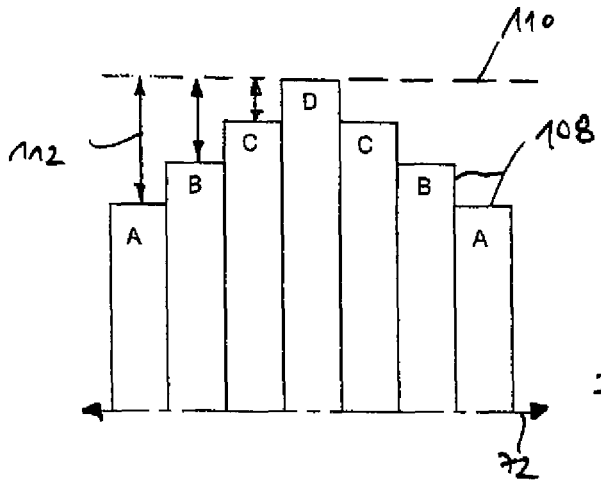
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Fig. 34

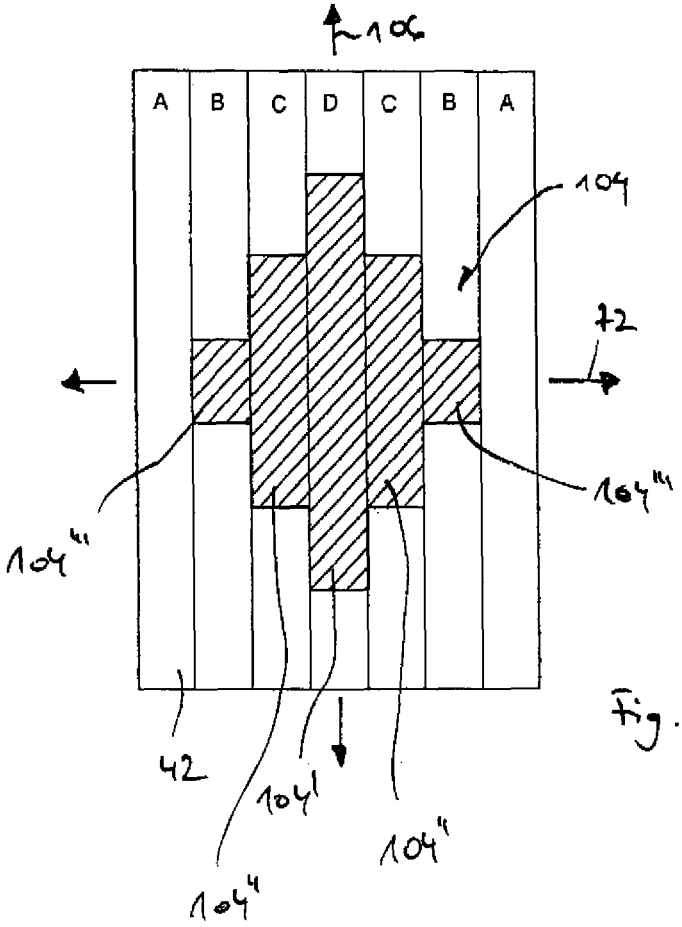
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Fig. 35

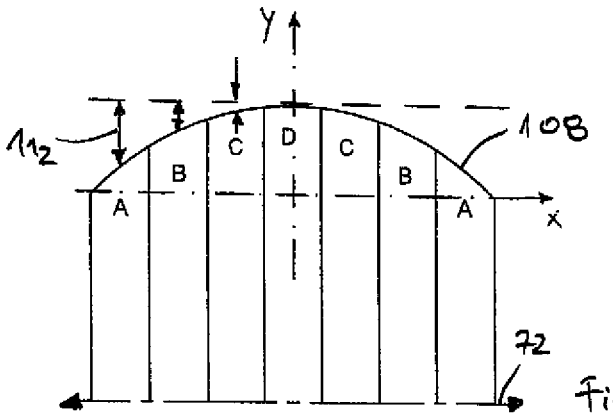

Fig. 36

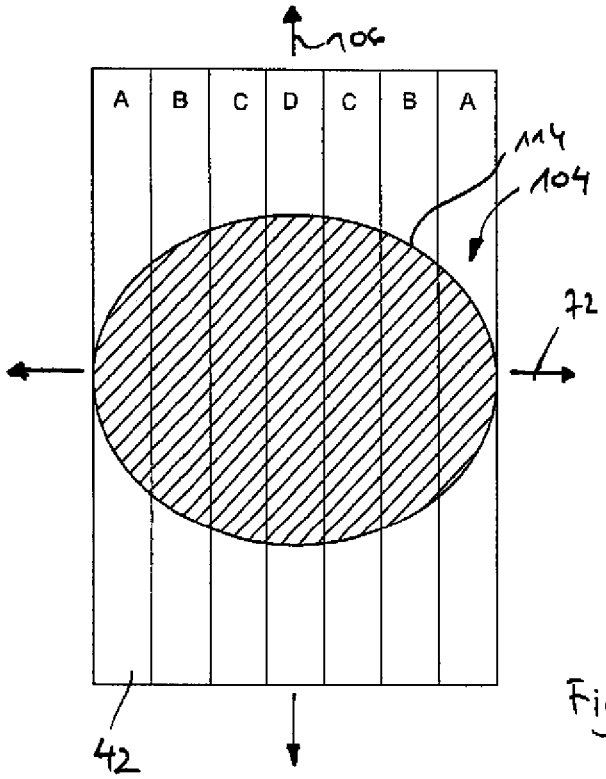

Fig. 37

BELT FINISHING DEVICE, BELT FINISHING SYSTEM AND METHOD FOR PRODUCING A BELT FINISHING DEVICE

CROSS-REFERENCES TO RELATED APPLICATIONS

This application claims the priority of European Patent Application EP 12 186 775.8, filed Oct. 1, 2012, pursuant to 35 U.S.C. 119(a)-(d), the content of which is incorporated herein by reference in its entirety as if fully set forth herein.

BACKGROUND OF THE INVENTION

The present invention relates to a belt finishing device with a pressing mechanism for pressing a finishing belt against a workpiece surface.

The following discussion of related art is provided to assist the reader in understanding the advantages of the invention, and is not to be construed as an admission that this related art is prior art to this invention.

In finish-machining, the workpiece surface to be machined is rotatably driven and relative movement between the workpiece and the finishing belt parallel to the workpiece axis is superimposed on this rotary motion. In this way, the workpiece surface is provided with a cross-cut structure characteristic for the finishing method.

The workpiece surfaces to be machined are in particular bearing surfaces of crankshafts or camshafts. These bearing surfaces must be manufactured with a high dimensional accuracy. In particular, the bearing surfaces of the crankshaft or camshaft should be made so as to ensure, in cooperation with the bearing surfaces of a crankshaft or camshaft housing or with the bearing surfaces of a connecting rod, low-backlash and low-friction bearings with high bearing surface proportions.

It has been observed that the above requirements cannot be optimally met with the conventional belt finishing devices. It would therefore be desirable and advantageous to obviate these prior art shortcomings and to provide an improved belt finishing device that enables the production of workpiece surfaces with high dimensional stability.

SUMMARY OF THE INVENTION

According to one aspect of the present invention, a belt finishing device includes a finishing belt, two bearing surfaces that are spaced-apart in a running direction of the finishing belt, and a pressing device for pressing the finishing belt against a workpiece surface, wherein the pressing device comprises a pressure belt that is supported on the two spaced-apart bearing surfaces, wherein at least one of a bearing surface and the pressure belt have a profile that deviates in a width direction of the finishing belt from a straight course.

The invention is based on the observation that, when using bearing surfaces known in the art, which have a straight profile in the width directions of the finishing belt (for example using cylindrical roller bearings and a pressure belt having a rectangular profile), the pressure belt is subjected to different tensile stress in the widthwise direction of the finishing belt. In a region with a higher tensile stress of the pressure belt, a higher pressing force is applied to a contact region of the finishing belt. In areas of the pressure belt with lower tension, a lower pressing force is applied to finishing belt areas supported on these areas. The different pressing forces cause the workpiece surface to be machined to deviate from a desired nominal contour.

According to the invention, the geometry of the workpiece surface to be machined is now influenced, namely by forming the profile of at least one of the bearing surfaces and/or of the pressure belt different from a linear course. A profile according to the invention deviating from a straight course has a predetermined shape which can not be provided by the surfaces of cylindrical roller bearings with the standard tolerances and by the pressure belts with a rectangular cross-section.

According to an advantageous feature of the present invention, the profile according to the invention of the at least one bearing surface and/or of the pressure belt has at least one profiled section which deviates by at least 10 micrometer, in particular by at least 20 micrometers from a mathematically ideal straight line.

Advantageously, the profile may have a curvature. For example, the profile of the pressure belt may have a curvature. Through contact of the pressure belt having a curved profile with the finishing belt, the finishing belt is also curved commensurately, namely about an axis of curvature extending parallel to a running direction of the finishing belt. In this way, the geometry of the workpiece surface to be finished can be specifically influenced. For example, the curvature of the pressure belt may be designed so that the workpiece surface to be finished attains a nearly perfect cylindrical shape. However, the curvature of the pressure belt may also be designed so as to produce a workpiece surface with a nominal shape deviating from a cylindrical shape. Specifically, convex workpiece surfaces can be produced. However, it is also possible to produce concave workpiece surfaces.

According to another advantageous feature of the present invention, at least one of the bearing surfaces may deviate from a straight course in the width direction of the finishing belt. For example, the profile of at least one of the bearing surfaces may be curved. When for example at least one of the bearing surfaces has a concave curvature, a higher tension is applied to the pressure belt in the outer side areas than in a central region. A finishing belt contacting this pressure belt is subjected to a higher pressing force in the outer side areas than in a central region. In this way, a workpiece surface can be produced which has a convex profile, i.e. which has a larger diameter in a central region than in the outer side regions.

The above-described options (at least one curved bearing surface, a pressure belt having a curved profile) may also be combined.

Within the context of the present invention, a bearing surface for supporting the pressure belt may advantageously be made entirely of the same material in order to define and produce a more dimensionally stable profile that deviates from a straight course.

Similarly, the pressure belt may have a pressing surface cooperating with the finishing belt, which is formed from only a single layer material or pressure belt material. This allows specifying and producing a particularly dimensionally stable profile of a pressure belt deviating from a straight course.

According to another advantageous feature of the present invention, the at least one bearing surface and/or the pressure belt may be continuous so that they completely support the finishing belt across its width. Alternatively, the at least one bearing surface and/or the pressure belt may have at least one discontinuity, so that the finishing belt is subjected to a lower pressing force, when viewed in the width direction, at least in the region of the discontinuity of the bearing surface and/or the pressure belt. The geometry of the workpiece surface can then be intentionally influenced so that less material is

removed in a rotation plane of the workpiece surface associated with the discontinuity and/or the pressure belt than in a laterally adjacent region.

The discontinuities may be, for example, pocket-shaped recesses and/or openings of at least one of the bearing surfaces and/or the pressure belt.

For example, at least one bearing surface may advantageously have recesses or grooves extending parallel to the running direction of the finishing belt. The bearing surface may also be formed by several separate bearing bodies, wherein the bearing bodies are arranged with a mutual offset in the width direction of the finishing belt.

According to another advantageous feature of the present invention, the pressure belt may have pocket-shaped recesses, for example in the region of the profile deviating from a straight course, so that a pressing surface facing the finishing belt is interrupted, whereas a back surface of the pressure belt facing away from the finishing belt is closed. Alternatively, the pressure belt may also be perforated, so that the pressure belt is interrupted not only on the front surface of the finishing belt in contact with the back side of the pressure belt, but also in the region of the back side of the finishing belt facing away from the pressure belt.

According to another advantageous feature of the present invention, at least one of the bearing surfaces may be formed by a bearing roller. This allows support of pressure belt over a high wrap angle.

According to another advantageous feature of the invention, the bearing roller may be floatingly mounted. This has the advantage that the course of the pressure belt and thus the course of the finishing belt can be readily adapted to workpiece surfaces having different diameters.

Advantageously, the bearing roller may be supported on a stationary bearing roller support system. This limits the degree of freedom of movement of a bearing roller.

Alternatively, at least one of the bearing surfaces may be formed by a stationary bearing element. Such a bearing element has an immovable bearing surface. This enables support of pressure belt with very low tolerances.

The pressure belt may also be movable relative to the bearing surfaces. However, according to another advantageous feature of the present invention, a fixing device for fixing the pressure belt relative to the bearing surfaces may be provided. This can further improve the dimensional accuracy of the workpiece surface to be produced.

Advantageously, a pressure belt may be provided with a back side facing away from the finishing belt having a profile that deviates from a linear course. However, at least the pressing surface of the pressure belt may have a profile that deviates from a linear course. In particular, only the pressing surface of the pressure belt has a profile that deviates from a linear course.

The pressing forces that can be transferred by the pressure belt to the finishing belt in the width direction of the finishing belt may be more easily controlled when the pressure belt is formed as an endless belt. Such pressure belt has a front active section whose front end interacts with the back side of the finish belt. Such endless belt is deflected in the region of spaced-apart bearing surfaces and transitions into a rear section that is spaced from the finishing belt.

According to another advantageous feature of the present invention, a rear section of the pressure belt may be supported or is supported by a pressure belt-support device. This creates another possibility for influencing the tension of the pressure belt along the width of the finishing belt.

According to another aspect of the invention, a belt finishing system includes an aforedescribed belt finishing device and a workpiece with a workpiece surface to be machined. At least one of the bearing surfaces and/or the pressure belt has at least one discontinuity, wherein the workpiece surface is also discontinuous in the region of a bore and wherein the position of the discontinuity is aligned with the position of the hole in the width direction of the finishing belt. Such belt finishing system is capable of producing crankshafts or camshafts that have a bore, in particular an oil outlet bore in the bearing surface. A plane of rotation associated with such bore experiences lower pressing forces during the finish-machining of the workpiece surface, so that the finishing belt presses with a lower pressing force against the workpiece in the region of the edge of the bore than in the laterally adjacent regions. This can prevent the finishing belt from penetrating too deeply into the bore and thus remove an excessive quantity of material in the region of the edge of the bore. Advantageously, a workpiece section that is already mechanically weakened in the region of the bore is then not further weakened, so that, in spite of such a bore, bearing surfaces having a comparatively high support surface proportion may be produced.

According to yet another aspect of the invention, in a method for manufacturing an aforedescribed belt finishing device, the nominal contour of a finished workpiece surface is determined and additionally at least one of the following method steps is performed:

- at least one of the bearing surfaces or a pressing surface of the pressure belt facing the finishing belt is provided with a profile that is identical to the nominal contour or has a more pronounced contour;
- at least one of the bearing surfaces and a pressing surface of the pressure belt facing the finishing belt is provided with a partial profile, wherein a superposition of the two partial profiles is identical to the nominal contour or has a more pronounced contour;
- nominal contour sections are defined and removal of material from the workpiece deviating from a circular cylindrical shape is determined for each of the nominal contour sections; at least one of the bearing surfaces and/or the pressure belt is provided with at least one discontinuity, wherein the discontinuity is associated with a nominal contour section having less material removed from the workpiece than an adjacent nominal contour section;
- nominal contour sections are defined, and for each of the nominal contour sections deviating from a circular cylindrical shape removal of material from the workpiece is determined; at least one of the bearing surfaces and/or the pressure belt is provided with discontinuities, which are each associated with a corresponding nominal contour section, wherein the discontinuities have different lengths measured in the running direction of the finishing belt, and discontinuities having shorter lengths are associated with nominal contour sections having greater material removal rates and discontinuities having greater lengths are associated with nominal contour sections having lower material removal rates.

According to another advantageous feature of the present invention, the profile and/or the superposition of the two partial profiles may have a more pronounced contour than the nominal contour, and the profile and/or the superposition of the two partial profiles may across an active width of the finishing belt delimit a segment of a circle, with a segment height that is greater by a factor from 1.5 to 25, preferably by a factor from 3 to 15, especially by a factor from 5 to 10, than

a segment height of a segment of a circle that is delimited by the nominal contour across the effective width of the finishing belt.

BRIEF DESCRIPTION OF THE DRAWING

Other features and advantages of the present invention will be more readily apparent upon reading the following description of currently preferred exemplified embodiments of the invention with reference to the accompanying drawing, which shows in:

FIG. **1** a side view of an embodiment of a belt finishing device according to the present invention;

FIG. **2** a side view of a section of the belt finishing device shown in FIG. **1** on an enlarged scale, illustrating a first workpiece having a first diameter;

FIG. **3** a view similar to FIG. **2**, illustrating a second workpiece with a second diameter that is smaller compared to the first diameter;

FIG. **4** a view taken along a section line IV-IV shown in FIG. **2**;

FIG. **5** a view taken along a section line V-V shown in FIG. **2**;

FIG. **6** a detail marked with VI in FIG. **5** on an enlarged scale;

FIG. **7** a view corresponding to FIG. **4** of another embodiment;

FIG. **8** a view of the embodiment of FIG. **7** corresponding to FIG. **5**;

FIG. **9** a view of the embodiment of FIG. **7** corresponding to FIG. **6**;

FIGS. **10***a*-**10***c* views corresponding to FIG. **9** in consecutive workpiece machining phases;

FIGS. **11***a* to **11***c* respective force profiles corresponding to the successive workpiece machining phases shown in FIGS. **10**-**10***c*;

FIG. **12** a side view of another embodiment of a belt finishing device, illustrating a first workpiece having a first diameter;

FIG. **13** a view corresponding to FIG. **12**, illustrating a second workpiece with a first diameter that is smaller in comparison with the second diameter;

FIG. **14** a view along a section line designated in FIG. **12** with XIV-XIV;

FIG. **15** an enlarged detail marked in FIG. **14** with XV;

FIG. **16** a perspective view of an embodiment of a bearing element for use in the belt finishing device of FIG. **12**;

FIG. **17** a side view of the bearing element according to FIG. **16**;

FIG. **18** a plan view of the bearing element of FIG. **16**;

FIG. **19** a view corresponding to FIG. **17** when using a pressure belt having a curved profile;

FIG. **20** a front view of the arrangement of FIG. **19**;

FIG. **21** a view of the arrangement of FIG. **19** along a section line designated in FIG. **19** with XXI-XXI;

FIG. **22** a perspective view of another embodiment of a bearing element for use in the belt finishing device of FIG. **12**;

FIG. **23** a side view of the bearing element of FIG. **22**;

FIG. **24** a plan view of the bearing element of FIG. **22**;

FIG. **25** a view corresponding to FIG. **23** when using a pressure belt having a straight profile in an uninstalled state;

FIG. **26** a front view of the arrangement of FIG. **25**;

FIG. **27** a view of the arrangement of FIG. **25** along a section line designated in FIG. **25** with XXVII-XXVII;

FIG. **28** a side view of another embodiment of an arrangement with a bearing element and a pressure belt;

FIG. **29** a front view of the arrangement of FIG. **28**;

FIG. **30** a view of the arrangement of FIG. **28** along a section line designated in FIG. **28** with XXX-XXX;

FIG. **31** a side view of another embodiment of an arrangement with a bearing element and a pressure belt;

FIG. **32** a front view of the arrangement of FIG. **31**;

FIG. **33** a view of the arrangement of FIG. **31** along a section line designated in FIG. **31** with XXXIII-XXXIII;

FIG. **34** a schematic view of an example of a nominal contour of a workpiece surface;

FIG. **35** a front view of an embodiment of a pressure belt for producing a nominal contour as shown in FIG. **34**;

FIG. **36** a schematic view of another example of a nominal contour of a workpiece surface; and

FIG. **37** a front view of an embodiment of a pressure belt for producing a nominal contour as shown in FIG. **36**.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Throughout all the figures, same or corresponding elements may generally be indicated by same reference numerals. These depicted embodiments are to be understood as illustrative of the invention and not as limiting in any way. It should also be understood that the figures are not necessarily to scale and that the embodiments are sometimes illustrated by graphic symbols, phantom lines, diagrammatic representations and fragmentary views. In certain instances, details which are not necessary for an understanding of the present invention or which render other details difficult to perceive may have been omitted.

Turning now to the drawing, and in particular to FIG. **1**, there is shown a belt finishing device designated by the reference numeral **10**. The belt finishing device is used for finish-machining an in particular rotationally symmetrical workpiece surface **12** of a workpiece **14**. The workpiece surface **12** is finish-machined with a finishing belt **16**.

A reservoir **17** is, for example, provided for the finishing belt **16**. Starting from the reservoir **17**, the finishing belt is guided on a guiding/deflection device **18** and deflected, and is in an active region **20** in contact with the workpiece surface **12** across a wrap angle (which is, for example, at least about 10°).

Adjacent to the active region **20** is a region **22**, where a spent finishing belt **16** is collected. Alternatively, the finishing belt **16** is deflected in the region **22** and fed to a second effective region **24** opposite the first active region **20**. The finishing belt is also in contact with the workpiece surface **12** in the second effective region **24** across a wrap angle (which is, for example, at least about 10°).

A guiding/deflection device **26** is adjacent to the active region **24**, from which the finishing belt **16** is fed to a collection region **28**.

Pressing devices **30** associated with a respective effective region **20**, **24** are provided for applying pressure to the finishing belt **16** in the active regions **20** and/or **24**. The pressing devices **30** are each held in respective holders **32**, which are preferably pivotable about respective associated pivot axes **34**.

The workpiece **14** is driven for rotation about a workpiece axis **36** (see FIG. **2**) during finish-machining. An oscillating relative movement parallel to the rotation axis **36** between the finishing belt **16** and the workpiece **14** is superimposed on this rotational movement.

FIG. **2** shows an enlarged view of a pressing device **30**, which has two spaced-apart bearing rollers **38** with radially outwardly oriented surfaces forming bearing surfaces **40** for supporting a pressure belt **42**.

The pressure belt **42** is formed as an endless belt. The pressure belt **42** cooperates with the finishing belt **16** by way of a front section **44**. Deflection sections **46** which cooperate with the bearing surfaces **40** and transition into a rear section **48** of the pressure belt **42** are located adjacent to the front section **44**. The rear section **48** is spaced apart from the front section **44**. The rear section **48** is supported in the region of a bearing surface **52** by a pressure belt support device **50**. The bearing surface **52** applies a supporting force acting on the rear section **48** of the pressure belt **42** in the direction of the workpiece **14**.

The bearing rollers **38** have mutually parallel bearing axles **54**. The bearing axles **54** are floatingly supported, for example by bearing elements **56** in the form of slots. The shape and arrangement of the bearing elements **58** (for example, the direction of the slots) is such that the bearing axles **54** are movable in a radial direction in relation to the workpiece axis **36**.

Preferably, the bearing rollers **38** are supported by a stationary bearing roller support device **60**. The device **60** includes, for example, a bearing surface **62** supporting the bearing rollers **38** through interposition of the pressure belt **42**. The devices **50** and **60** may be formed integrally as a single piece. The bearing surfaces **52** and **62** preferably transition into each other continuously (without kinks).

The pressing device **30** is suitable for workpieces **14** having different diameters. For example, when instead of the workpiece **14** (see FIG. **2**), a workpiece **14'** with a smaller diameter (see FIG. **3**) is finish-machined, its workpiece axis **36'** is displaced toward the finishing belt **16**. At the same time, the wrap angle of the effective region **24** increases. In addition, the bearing axles **54** of the bearing rollers **38** shift further in the direction of the workpiece **14'**.

The bearing rollers **38** are rotationally symmetric in relation to the bearing axles **54** and have in profile curved convex bearing surfaces **40** (see FIG. **4**). The bearing surface **40** is operative to support a back side **64** (see FIG. **6**) of the pressure belt **42**.

The pressure belt **42** has a pressing surface **66** facing away from the back side **64**, which applies pressing forces to a back side **68** of the finishing belt **16**, causing an effective surface **70** of the finishing belt **16** provided with finish material to be pressed against the workpiece surface **12** of the workpiece **14** to be finish-machined

The pressure belt **42** has in an undeformed initial state a rectangular cross-section. Thus, the pressing surface **66** in the undeformed state of the pressure belt **42** has a straight course. The pressure belt **42** is elastically deformable and is in the turn sections **46** (see FIG. **2**) with its back surface **64** in two-dimensional contact with the bearing surface **40**. This deforms the pressure belt **42**, so that the pressing surface **66** has a curved profile corresponding to the curvature of the bearing surface **40**. The finishing belt **16** in contact with the pressure belt **42** also deforms commensurate with the curvature of the pressing surface **66** of the pressure belt **42**, so that the effective region **70** of the finishing belt **16** has a convex curvature, enabling the production of a workpiece surface **12** with a concave curvature. The bearing surfaces **40** and the pressing surface **66** of the pressure belt **42** thus have a curved profile that is different from a straight course in the width direction **72** of the finishing belt **16**.

The above description applies likewise for an embodiment illustrated in FIGS. **7-9**. However, the bearing surfaces **40** of the bearing rollers **38** in this embodiment have a concave curvature. Interposing the pressure belt **42** creates a concave effective surface **70** of the finishing belt **16**, so that a workpiece surface **12** of the workpiece **14** with a convex curvature can be produced.

Preferably, a radius of curvature of a bearing surface **40** with a convex curvature (see FIG. **4**) is between approximately 1000 mm and approximately 6000 mm. With a bearing width of about 20 to 25 mm, a suitable chord height (that is a maximum depression relative to a circular cylindrical shape) is from about 0.02 to 0.05 mm.

A radius of curvature of a bearing surface **40** with a concave curvature (see FIG. **7**) is preferably between approximately 1000 mm and approximately 6000 mm. With a bearing width of about 20 to 25 mm, a suitable chord height (that is a maximum depression relative to a circular cylindrical shape) is from about 0.02 to 0.05 mm.

FIG. **10***c* shows a diagram corresponding to FIG. **9**. FIGS. **10***b* and **10***a* show workpiece processing phases preceding the state of FIG. **10***c*.

In the state shown in FIG. **10***a*, the workpiece surface **12** of the workpiece **14** is cylindrical. Due to the curvature of the effective surface **70** of the finishing belt **16**, only edge regions **74** of the finishing belt **16** are initially in contact with corresponding edge regions **76** of the workpiece **14**. These regions apply correspondingly high opposing forces **78** (see FIG. **11***a*) on the finishing belt **16**. With progressive machining the workpiece surface **12**, the opposing forces **78** move further toward a central region **80** (see FIG. **11***b*) of the workpiece **14**.

FIG. **11***c* shows a state in which the workpiece surface **12** assumes a curved nominal contour. In this state, the concave radius of curvature of the active surface **70** of the finishing belt **16** communicates with the convex radius of curvature of the workpiece surface **12** of the workpiece **14**, with the working surface **70** being in full contact with the workpiece surface **12** of the workpiece **14** across the width direction **72**.

Regarding the pressing devices **30** described hereinafter with reference to FIGS. **12** to **27**, reference is made to the foregoing description of the pressing devices **30** illustrated in FIGS. **1** to **11***c*. Subsequently, particular differences from the above-described pressing devices **30** to be discussed.

The pressing devices **30** according to FIGS. **12** and **13** have instead of the bearing rollers **38** a stationary bearing element **82** with immovable bearing surfaces **40**.

These bearing elements **82** are shown, for example, in a perspective view in FIGS. **16** and **22**. The bearing elements **82** have in the region between two spaced-apart bearing surfaces **40** a constriction **84** associated with the effective region **20** of the finishing belt **16**. The constriction **84** is so large that the back side **64** of a front section **44** of the pressure belt **42** arranged at the level of the active section **20** of the finishing belt **16** is spaced from the bearing element **82**, forming a clearance **86** (see FIGS. **12** and **13**). The clearance **86** forms an escape space for the front section **44** of the pressure belt **42** when in contact with part of the periphery of the workpiece surface **12** of a workpiece **14** to be finished. Depending on the size of the workpiece **14** and of the diameter of the surface of the workpiece **12** to be machined, the profile of the pressure belt **42** adapts to the profile of the workpiece surface **12** to be machined (for example, to large workpieces **14**, see FIG. **12** and to smaller workpieces **14'**, see FIG. **13**).

The bearing elements **82** have a bearing surface **52** disposed on the side facing away from the constriction **84**.

The pressing device **30** according to FIGS. **12** and **13** further includes a fixing device, generally designated with the numeral **87**, for fixing the pressure belt **42** relative to the bearing surfaces **40**. The fixing device **87** includes, for example, an actuating element **88** in the form of a screw that

presses a fixing element **90** against the pressure belt **42**, and in turn presses the pressure belt **42** against the bearing surface **52** (see FIGS. **14** and **15**).

The bearing element **82** has, for example, a one-piece bearing element **92** extending in the width direction **72** of the finishing belt **16** (see FIG. **15**) between opposing side surfaces **94** and **96** (see FIG. **18**).

The bearing body **92** may be connected, for example with screws **98**, with mounting elements **100** (see FIGS. **15** and **12**) which serve to fasten the bearing element **82** to the holders **32** (see FIG. **1**). The mounting elements **100** may be connected with a frame **102** (see FIGS. **12** and **13**), which is in turn connected to a holder **32**.

In the embodiment of a pressing device **30** shown in FIGS. **12** to **21**, the bearing surfaces **40** of the bearing element **82** have a straight course. These bearing surfaces **40** correspond to surface sections of a cylindrical envelope between their transition to the constriction **84** and to the bearing surface **52**. These surface surfaces **40** serve to support a pressure belt **42** having a pressing surface **66** with a curved profile, in particular is concave profile (see FIG. **15**).

The bearing surface **52** of the bearing element **82** illustrated in FIGS. **16** to **21** preferably extends in a straight plane.

In the embodiment of a bearing element **82** and a pressure belt **42** illustrated in FIGS. **12** to **15** and for use in a pressing device **30** shown in FIGS. **22** to **27**, the bearing surfaces **40** have a curved profile, in particular a profile with a concave curvature. Such bearing elements **82** can be used, as shown in particular in FIGS. **25** to **27**, in conjunction with a pressure belt **42**, which has in an undeformed initial state a rectangular cross-section with a profiled straight pressing surface **66**. When using such a pressure belt **42**, the shape of curvature of the bearing surface **40** is transferred to the pressing surface **66** and to the finishing belt **16**, and to the workpiece surface **12** to be machined.

However, the support element **82** according to FIGS. **22** to **24** can alternatively be used in conjunction with a pressure belt **42**, which has a pressing surface **66** with a curved profile (such a pressure belt **42** is shown for example in FIG. **21**).

For the embodiments described below with reference to FIGS. **28** to **33**, reference is made to the above description. The pressure belts **42** according to FIGS. **28** to **33** have, in contrast to the above-described pressure belts **42**, openings **104** which are arranged in particular at the height of the constriction **84** and thus at the height of the effective region **20** of the finishing belt **16**. Only a single opening **104** (see FIG. **29**) may be provided. Alternatively, a plurality of openings **104** may be provided (see FIG. **32**).

The openings **104** extend in the width direction **72** of the finishing belt **16** as well as in the running direction **106** of the finishing belt **16**.

When only a single opening **104** is provided, this opening may preferably be substantially elliptic or rhombic.

FIG. **34** shows on an enlarged scale a nominal contour **108** of a workpiece **14** which is shown across the width direction **72** of the finishing belt **16**. The nominal contour **108** deviates from a circular cylindrical shape **110**, namely by different quantities of removed workpiece material **112**. The largest quantities of workpiece material **112** are removed from the outside nominal contour sections A, a lesser amount of workpiece material is removed from the nominal contour sections B, still smaller amounts of workpiece material are removed from the nominal contour sections C, and no or only an insignificant amount of workpiece material is removed from the nominal contour section D.

For dimensioning a discontinuity **104** shown in FIG. **35**, a pressure belt **42** with successive belt sections (ABCDCBA), as viewed in the width direction **72** of the finishing belt **16**, is provided. A belt section D, which cooperates with a nominal contour section D of the nominal contour **108** of the workpiece **14**, has a discontinuity **104'**, which is longer in the running direction **106** of the finishing belt **16** than discontinuities **104"** associated with belt sections C that cooperate with corresponding nominal contour sections with greater material removal rates **112**. Overall, for example, an arrangement shown in FIG. **35** is obtained, wherein mutually adjacent discontinuities **104**, **104'**, **104"**, **104'"**together form a continuous discontinuity **104**. Alternatively, the discontinuities **104**, **104'**, **104"**, **104"** may also be arranged separately.

In a further refinement of the dimensions of a discontinuity **104**, the nominal contour **108** of a workpiece **14** may also be described in the form of, for example, a continuous and kink-free function, as indicated in FIG. **36** by a coordinate system. For example, such a function may be a circle or a logarithmic function. Depending on the function, the course **114** of an opening **104** can then be determined (see FIG. **37**).

With the discontinuities **104** shown for example in FIGS. **35** and **37**, different material removal rates **112** can be realized in the width direction **72** of the finishing belt **16**. Because the pressure belt **42** has in the running direction **106** a longer discontinuity in a central section D, the finishing belt **16** is pressed in this region with a lower tension against the workpiece **12**, resulting in a smaller quantity of removed material. Conversely, the openings are shorter in lateral belt sections (for example, in belt sections B), as viewed in the running direction **106** of the finishing belt **16**, so that the pressure belt **42** is pressed against the finishing belt **16** in these belt sections with greater force, resulting in greater material removal in these areas.

While the invention has been illustrated and described in connection with currently preferred embodiments shown and described in detail, it is not intended to be limited to the details shown since various modifications and structural changes may be made without departing in any way from the spirit and scope of the present invention. The embodiments were chosen and described in order to explain the principles of the invention and practical application to thereby enable a person skilled in the art to best utilize the invention and various embodiments with various modifications as are suited to the particular use contemplated.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims and includes equivalents of the elements recited therein:

1. A belt finishing device, comprising:

a finishing belt,

two bearing surfaces that are spaced-apart in a running direction of the finishing belt, and

a pressing device for pressing the finishing belt against a workpiece surface, wherein the pressing device comprises a pressure belt that is supported on the two spaced-apart bearing surfaces, wherein at least one of the two bearing surfaces and the pressure belt have a profile that deviates in a width direction of the finishing belt from a straight course,

wherein at least one bearing of the two bearing surfaces or the pressure belt, or both, have at least one discontinuity in the form of a pocket-shaped recess or an opening.

2. The belt finishing device of claim **1**, wherein the profile is curved.

3. The belt finishing device of claim **1**, wherein at least one of the bearing surfaces comprises a bearing roller.

4. The belt finishing device of claim **3**, wherein the bearing roller is floatingly supported.

5. The belt finishing device of claim 3, further comprising a stationary bearing roller support device supporting the bearing roller.

6. The belt finishing device of claim 1, wherein at least one of the bearing surfaces is formed by a stationary bearing element.

7. The belt finishing device of claim 1, further comprising a fixing device for fixing the pressure belt relative to the bearing surfaces.

8. The belt finishing device of claim 1, wherein the profile is disposed on a pressing surface of pressure belt facing the finishing belt.

9. The belt finishing device of claim 1, wherein the pressure belt is shaped as an endless belt.

10. The belt finishing device of claim 9, further comprising a pressure belt support device supporting a rearward section of the pressure belt, wherein the rearward section is spaced from the finishing belt and extends between the two spaced-apart bearing surfaces.

11. A belt finishing system, comprising:

a belt finishing device having a finishing belt, two bearing surfaces that are spaced-apart in a running direction of the finishing belt, and a pressing device for pressing the finishing belt against a workpiece surface, wherein the pressing device comprises a pressure belt that is supported on the two spaced-apart bearing surfaces, wherein at least one of the bearing surfaces or the pressure belt, or at least one of the bearing surfaces and the pressure belt, has a profile that deviates in a width direction of the finishing belt from a straight course, and

a workpiece having a workpiece surface to be finish-processed, wherein the workpiece surface is interrupted in a region of a bore,

wherein at least one of the two bearing surfaces and the pressure belt have at least one discontinuity, and wherein a position of the discontinuity in the width direction of the finishing belt matches to a position of the bore.

12. A method for producing a belt finishing device having a finishing belt, two bearing surfaces that are spaced-apart in a running direction of the finishing belt, and a pressing device for pressing the finishing belt against a workpiece surface, wherein the pressing device comprises a pressure belt that is supported on the two spaced-apart bearing surfaces, wherein at least one of the two bearing surfaces and the pressure belt have a profile that deviates in a width direction of the finishing belt from a straight course, the method comprising:

determining a nominal contour of a finish-machined workpiece surface, and

performing additionally at least one of the following steps:

providing at least one of the two bearing surfaces or a pressing surface of the pressure belt facing the finishing belt with a profile that is more pronounced than the nominal contour;

providing each of at least one of the two bearing surfaces and a pressing surface of the pressure belt facing the finishing belt with a corresponding partial profile, wherein a superposition of the partial profiles is identical to the nominal contour;

defining first nominal contour sections and determining for each of the first nominal contour sections a removal of material from the workpiece that is different from a circular cylindrical shape; providing at least one of a bearing surface and the pressure belt with at least one discontinuity, wherein the at least one discontinuity is associated with a first nominal contour section having a lesser quantity of material removed from the workpiece than an adjacent nominal contour section;

defining second nominal contour sections, and determining for each of the second nominal contour sections a removal of material from the workpiece that is different from a circular cylindrical shape; providing at least one of the two bearing surfaces and the pressure belt with discontinuities, with each discontinuity being associated with a corresponding second nominal contour section, wherein the discontinuities have different lengths as measured in a running direction of the finishing belt, and wherein discontinuities having shorter lengths are associated with the second nominal contour sections having greater material removal rates and discontinuities having greater lengths are associated with the first nominal contour sections having lower material removal rates.

13. The method of claim 12, wherein the profile or the superposition of the partial profiles have a contour that is more pronounced than the nominal contour, and wherein the profile or the superposition of the partial profiles delimits a segment of a circle, as viewed across an effective width of the finishing belt, with a segment height being greater by a factor from 1.5 to 25 than a segment height of a segment of a circle that is delimited by the nominal contour, as viewed across the effective width of the finishing belt.

14. The method of claim 13, wherein the segment height is greater by a factor from 3 to 15.

15. The method of claim 13, wherein the segment height is greater by a factor from 5 to 10.

16. A belt finishing device for finish-processing a workpiece, comprising:

a workpiece having a workpiece surface to be finish-processed,

a finishing belt,

two bearing surfaces that are spaced-apart in a running direction of the finishing belt, and

a pressing device for pressing the finishing belt against the workpiece surface, wherein the pressing device comprises a pressure belt that is supported on the two spaced-apart bearing surfaces, wherein at least one of the two bearing surfaces and the pressure belt have a profile that deviates in a width direction of the finishing belt from a straight course,

wherein the workpiece is during finish-machining rotated about a workpiece axis and an oscillating relative movement of the workpiece parallel to the workpiece axis is superimposed on the rotation of the workpiece, such that the workpiece surface is provided with a cross-cut structure characteristic for finishing method.

17. A belt finishing device for finish-processing a workpiece, comprising:

a finishing belt,

two bearing surfaces that are spaced-apart in a running direction of the finishing belt, and

a pressing device for pressing the finishing belt against a workpiece surface, wherein the pressing device comprises a pressure belt that is supported on the two spaced-apart bearing surfaces, wherein at least one of the two bearing surfaces, or the pressure belt, or both have a profile that deviates in a width direction of the finishing belt from a straight course, wherein the bearing surfaces are immovable and formed by a stationary bearing element.

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